STATE OF ILLINOIS
DEPARTMENT OF
REGISTRATION AND EDUCATION
~~FRANK G. THOMPSON~~*, DIRECTOR
SPRINGFIELD

1582174

STATE OF ILLINOIS
Adlai E. Stevenson ~~DWIGHT H. GREEN~~, GOVERNOR
STATE WATER SURVEY DIVISION
ARTHUR M. BUSWELL, CHIEF
URBANA, ILL.

August 26, 1949

MONSANTO CHEMICAL CO.

East St. Louis, Illinois

Subject: Conference on industrial use of water
Date: August 18, 1949
Personnel: Mr. J. F. Stickley - M.C.C. Assistant Plant Manager
Mr. J. P. Bufe - M.C.C. Utility Engineer for power plant and water supply
Mr. H. E. Hudson - S.W.S. Civil Engineer
Mr. T. E. Larson - S.W.S. Chemist
Mr. R. P. Strout - S.W.S. Mechanical Engineer

Products: Chlorine and caustic soda ($NaOH$)
Sulfuric acid (Numerous other minor products)

Chlorine is produced by a gas by passing an electric current through a solution of common salt in a Nelson Cell. The resulting caustic soda remains in solution.

Sulfuric acid is produced by the contact or catalytic process in which burning sulfur forms SO_3 in the presence of vanadium catalyst combining with 98% sulfuric acid H_2SO_4, to form 99% sulfuric acid.

The municipal water company supplies approximately 2,000,000 gpd of soft water (130 ppm) to the plant.

Municipal water is drawn from the Mississippi River.

City water is used for fire supply as insurance Co. considers it most reliable.

City water used in plant for sanitary purposes, as solvent in process water (dissolves salts), as make-up in evaporative cooling units.

The plant draws about 10 Mgd. of water from its own wells.

The water level is reported not to have changed materially over a period of 40 years.

Well water is highly mineralized (13000 ppm) containing much iron (15-20 ppm.) which tends to clog heat exchangers particularly if exposed to air.

Water from 2 wells is treated with sulfur dioxide to delay precipitation of iron sludge.

Concentration of SO_2 is maintained at 7 ppm.

Well water is used only for heat transfer cooling. In the cooling process the water is limited to a 25° F. temperature rise as a greater temperature increase would result in precipitation of the iron and $CaCO_3$ sludge, within equipment.

Both municipal and well supply are metered but plant desires a greater number of meters at points of use.

The temperature range of chemical processes is from -10° C. to 250° C.

The water system represents 2 to 4 percent of the total plant investment.

It is estimated that well water costs between 4 and 5 cents per 1000 gallons.

Major water equipment used for cooling consisted of:

Cell forced draft cooling towers for
1 spray pond for caustic separation
1 cascade evaporative condenser for SO_2 cooling.

R. P. Strout

DISPOSAL WELL DESIGN

FOR

W. G. KRUMMRICH PLANT

MONSANTO COMPANY

Sauget, Illinois

February 15, 1971

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PURPOSE

The purpose of this report is to provide the supporting data required to secure a permit to drill, test and complete an industrial waste disposal well at Monsanto's W. G. Krummrich Plant at Sauget, St. Clair County, Illinois.

Plans and design data are included to meet the requirements set forth in general terms in "Administrative and Technical Procedures Controlling the Installation and Operation of Deep Well Injection of Industrial Wastes in Illinois" (Illinois Sanitary Water Board - January 13, 1968). Details are included to satisfy the specific requirements discussed in C. W. Klassen's letter to G. L. Bratsch of August 17, 1970 and the points raised in the meeting of August 31, 1970.

This report is, therefore, a continuation of the feasibility study of, March 27, 1970 previously submitted to the Sanitary Water Board by Monsanto.

PROPOSAL

The Monsanto Corporation, with the assistance of its affiliate, Monsanto Enviro-Chem Systems,; proposes to drill a test well on 3.859 acres of its property known as "Part of Lot 122 of Cahokia Commonfields" adjoining its W. G. Krummrich Plant near Sauget, St. Clair County, Illinois. The test well will, as described in this report, develop sufficient information to determine its suitability for use as a disposal well.

Should the geology prove to be satisfactory, Monsanto proposes to complete the test well immediately as a waste disposal well in the manner described herein.

The exact location of Part Lot 122 is shown on the following three maps and is described in detail as follows:

> Part of lot numbered One Hundred twenty-two (122) of the "CAHOKIA COMMONFIELDS"; reference being had to part of the plat thereof recorded in the Recorder's office of St. Clair County, Illinois in Book of Plat "E" on pages 16 and 17, more particularly described as follows, to-wit:
>
> Commencing at the point of intersection of the Northwesterly line of lot seventy-seven (77) extended Southwesterwardly with the Northeasterly line of Monsanto Avenue, said point also being distant sixty (60) feet Northeastwardly and measured

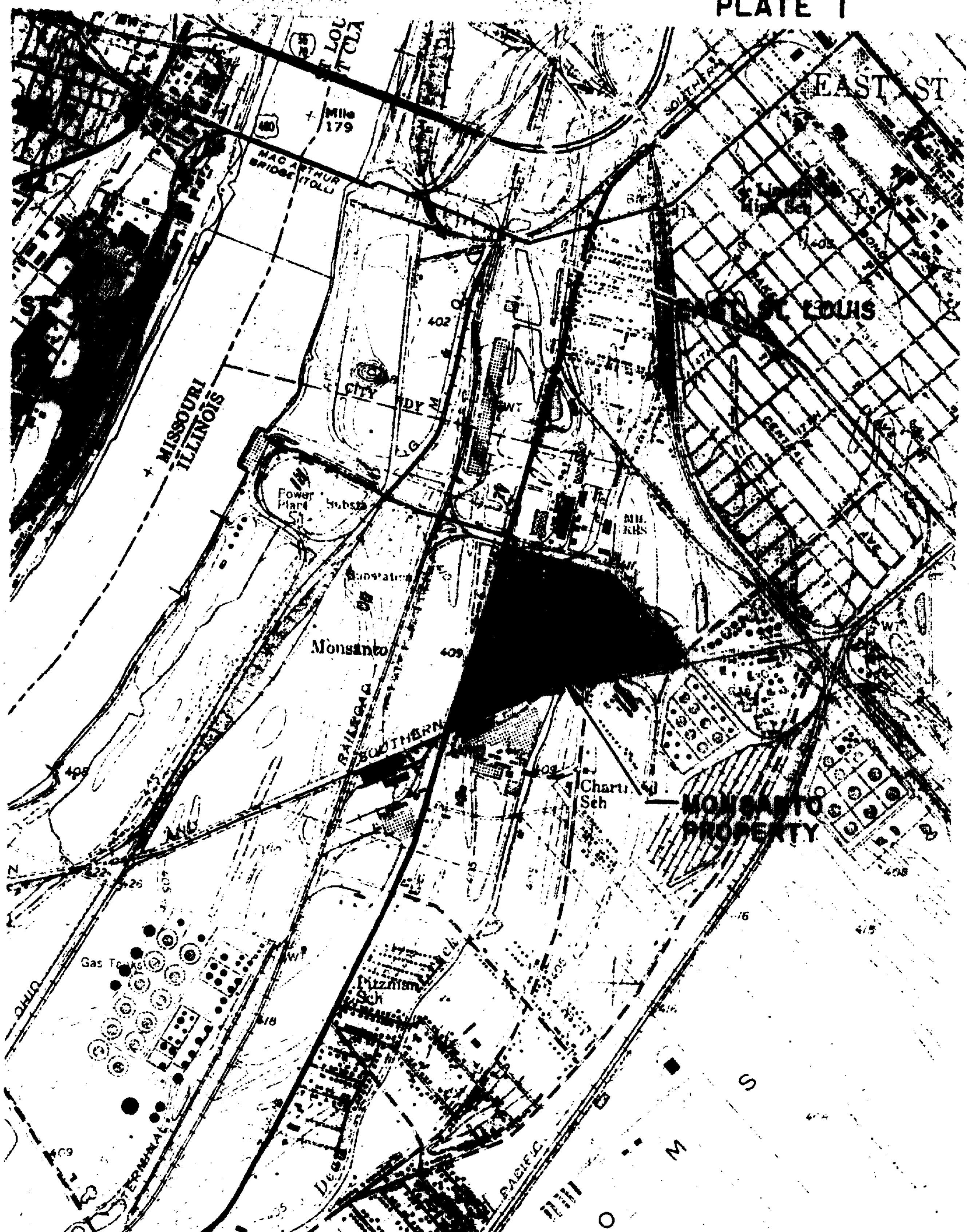
along the said Southwesterly extension of the Northwesterly line of lot Seventy-seven(77), from the Southwesterly line of lot One Hundred Twenty Two (122); thence in a Northeasterly direction along the said Southwesterly extension of the Northwesterly line of lot Seventy-Seven (77), a distance of Three Hundred and Eighteen and Five tenths (318.5) feet to the intersection of said line with the Northeasterly line of lot One Hundred Twenty-Two (122); thence Southeastwardly along the Northeasterly line of lot One Hundred Twenty-Two (122) a distance of Five Hundred Forty-One and Forty-three Hundredths (541.43) feet to the Intersection of said line with the Northwesterly line of the former right of way of the East St. Louis, Columbia and Waterloo Electric Railway; this point being also the intersection of said former right of way line with the Southwesterly line of lot Seventy-Seven (77); then Southwestwardly along the straight extension of the Northwesterly line of said former right of way of the East St. Louis, Columbia and Waterloo Electric Railway, a distance of Two Hundred Forty-Six (246.0) feet to a point; thence Westwardly making an interior angle of 127° 58' 30" with the last described line, a distance of One Hundred Eighteen and three tenths (118.3) feet to a point in the Northeasterly line of Monsanto Avenue; thence Northwestwardly along the Northeasterly line of Monsanto Avenue, a distance of Four Hundred

Forty-seven and Ninety-five Hundredths (447.95) feet to the point of beginning, and containing Three and Eight Hundred Fifty-nine thousandths (3.859) acres, more or less.

Situated in the County of St. Clair and State of Illinois.

LOCATION PLAN
MONSANTO CO. KRUMMRICH PLANT
EAST ST. LOUIS ILL.

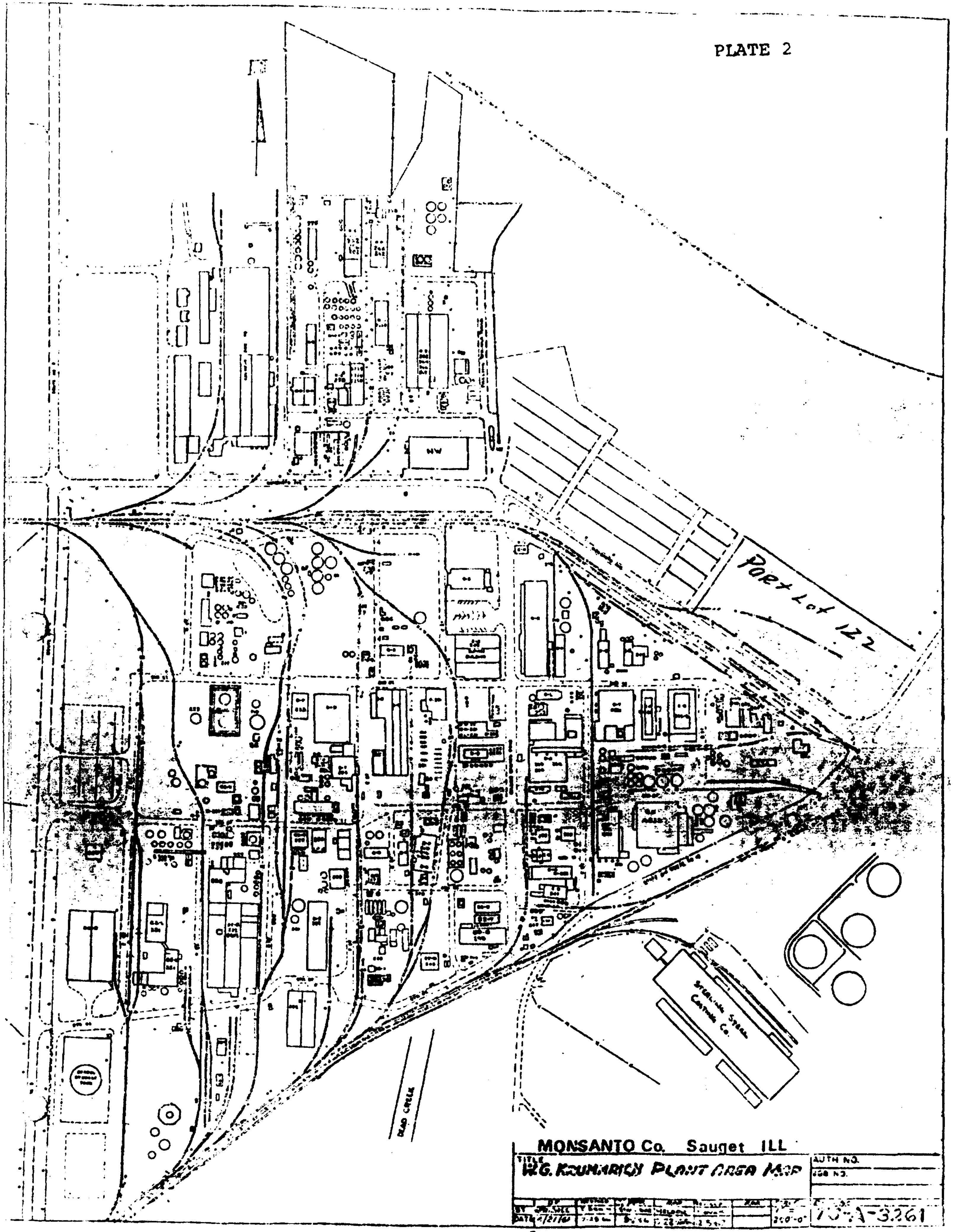
PLATE I

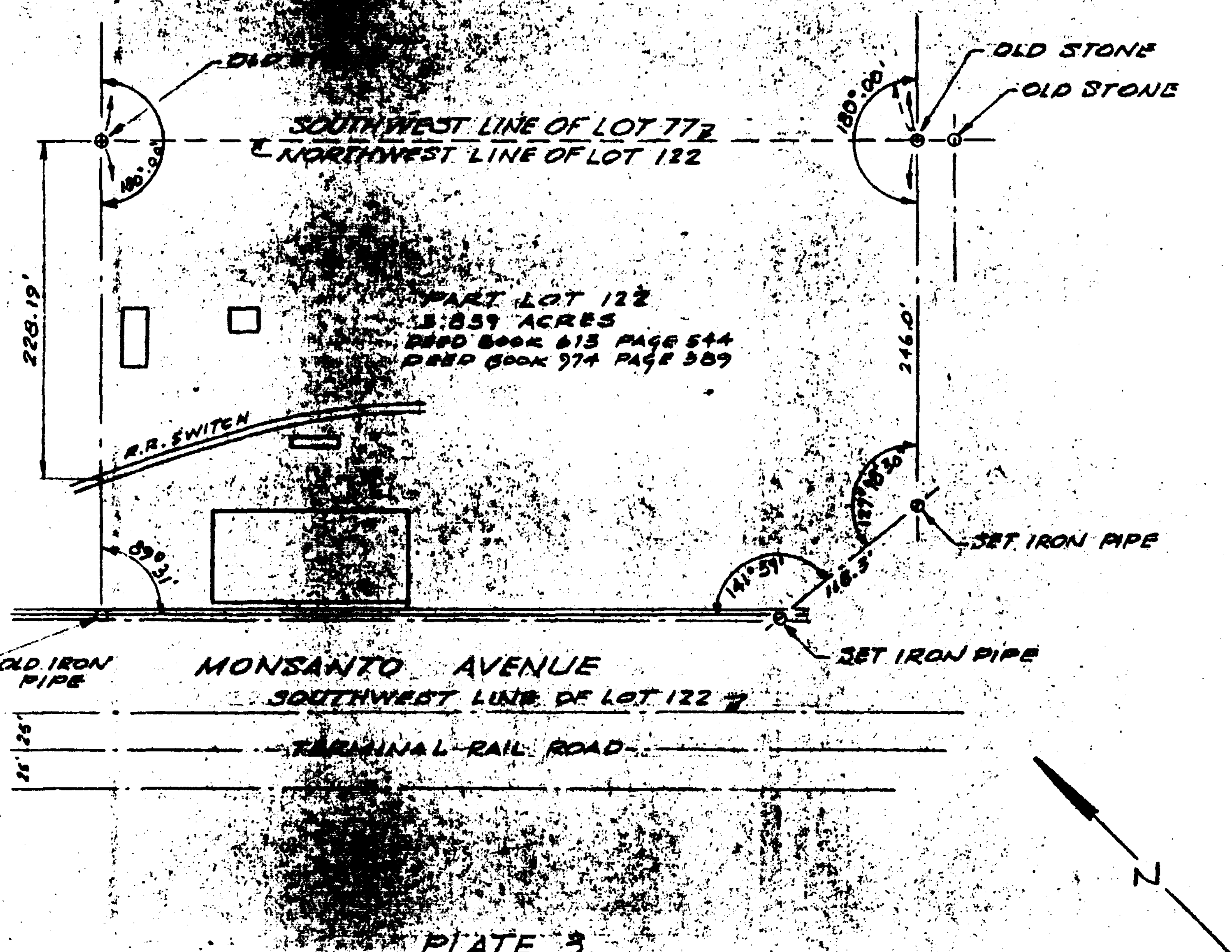


NOTE: MAP SECTION TAKEN FROM CAHOKIA QUADRANGLE U.S.G.S.

SCALE 1:24000

PLATE 2


Part Lot 122
NW
Sterling Steel Castings Co.
DEAD CREEK
MONSANTO Co. Sauget ILL
TITLE W.G. KRUMMRICH PLANT AREA MAP
AUTH NO.
JOB NO.



OLD STONE
OLD STONE
SOUTHWEST LINE OF LOT 77 2
NORTHWEST LINE OF LOT 122
180°00'
180°00'
228.19'
246.0'
PART LOT 122
3.859 ACRES
DEED BOOK 613 PAGE 544
DEED BOOK 974 PAGE 389
R.R. SWITCH
89°31'
141°59'
168.3'
SET IRON PIPE
SET IRON PIPE
OLD IRON PIPE
MONSANTO AVENUE
SOUTHWEST LINE OF LOT 122
TERMINAL RAIL ROAD
N

PLATE 3

<u>CONCLUSIONS</u>

(1) The St. Peter sandstone at 1600', appears to be suitable for injection of sulfuric acid wastes in the range of 50 to 150 gpm.

$\boxed{\text{170 gpm}}$
see p 20

(2) The St. Peter can be tested for both permeability of the rock and mineralization of the connate water before running casing and completing the well.

(3) If the St. Peter is unsuitable for any reason, the Mt. Simon sandstone (3700-4000') can also be tested for permeability and water mineralization.

(4) After testing, a safe completion (or abandonment) can be made which will protect all fresh water resources.

RECOMMENDATIONS

(1) It is recommended that a well be drilled to the St. Peter sandstone and that this horizon be thoroughly tested.

(2) If the St. Peter is sufficiently permeable to accept 50 gpm or more, and carries water in excess of 10,000 ppm total dissolved solids; it is recommended that the well be completed as a disposal well in this horizon.

(3) If the St. Peter is unsuitable for any reason, it is recommended that the Mt. Simon sandstone be tested.

(4) If the Mt. Simon is suitable; it is recommended that the well be completed in this horizon as a disposal well, with an intermediate liner casing to protect the St. Peter should this zone require it.

(5) It is recommended that the detailed design of the pretreatment plant and injection system (including tubing) be deferred until precise design parameters are available from well tests.

BACKGROUND

On March 27, 1970 a Feasibility Study was prepared in which Monsanto proposed to dispose of several streams of waste sulfuric acid (up to 155 gpm) via deep well at its Sauget, Illinois plant. The primary objective was the St. Peter sand (-1200' sub-sea) with a secondary objective being the Mt. Simon (-3600' sub-sea) if the St. Peter was unsuitable.

The report was submitted to Illinois Sanitary Water Board and comments were requested. A joint review by all interested state agencies was completed and, on August 7, 1970; comments on the proposal were sent to Monsanto by C. W. Klassen. A meeting was arranged for August 31, 1970 at Springfield.

The questions raised can be summarized briefly as follows:

(1) Does the St. Peter carry brine in excess of 10,000 ppm total dissolved solids at this location? If so, how does Monsanto propose to prove it? If not, how does Monsanto propose to protect this zone?

(2) How does Monsanto propose to test the intake capacity of the well? What safeguards against disposal above fracturing pressure does Monsanto propose?

(3) What degree of pretreatment does Monsanto propose for this waste?

(4) What are the details of Monsanto's proposed logging, coring, and testing program?

(5) What are the exact physical and chemical properties of the waste to be injected?

OBJECTIVES

The objectives of the well proposed in this study are:

(1) To test the suitability of the St. Peter as a disposal zone.

(2) To test the suitability of the Mt. Simon as a disposal zone if the St. Peter is unsuitable.

(3) To complete the well safely in the shallowest suitable horizon, if one exists.

(4) To plug the well securely if no suitable horizon exists.

It is proposed to achieve these objectives by following a flexible drilling program with alternative branches. Information developed during drilling will direct which alternative will be followed. The program described in detail in Appendix I can be summarized as follows:

Alternate 1

The St. Peter will be thoroughly tested and, if suitable, the well will be completed in this horizon.

Alternate 2

If the St. Peter carries brine in excess of 10,000 ppm total dissolved solids but lacks sufficient permeability, the well will test the Mt. Simon. If this zone is satisfactory, a conventional completion in the Mt. Simon will be made.

Alternate 3

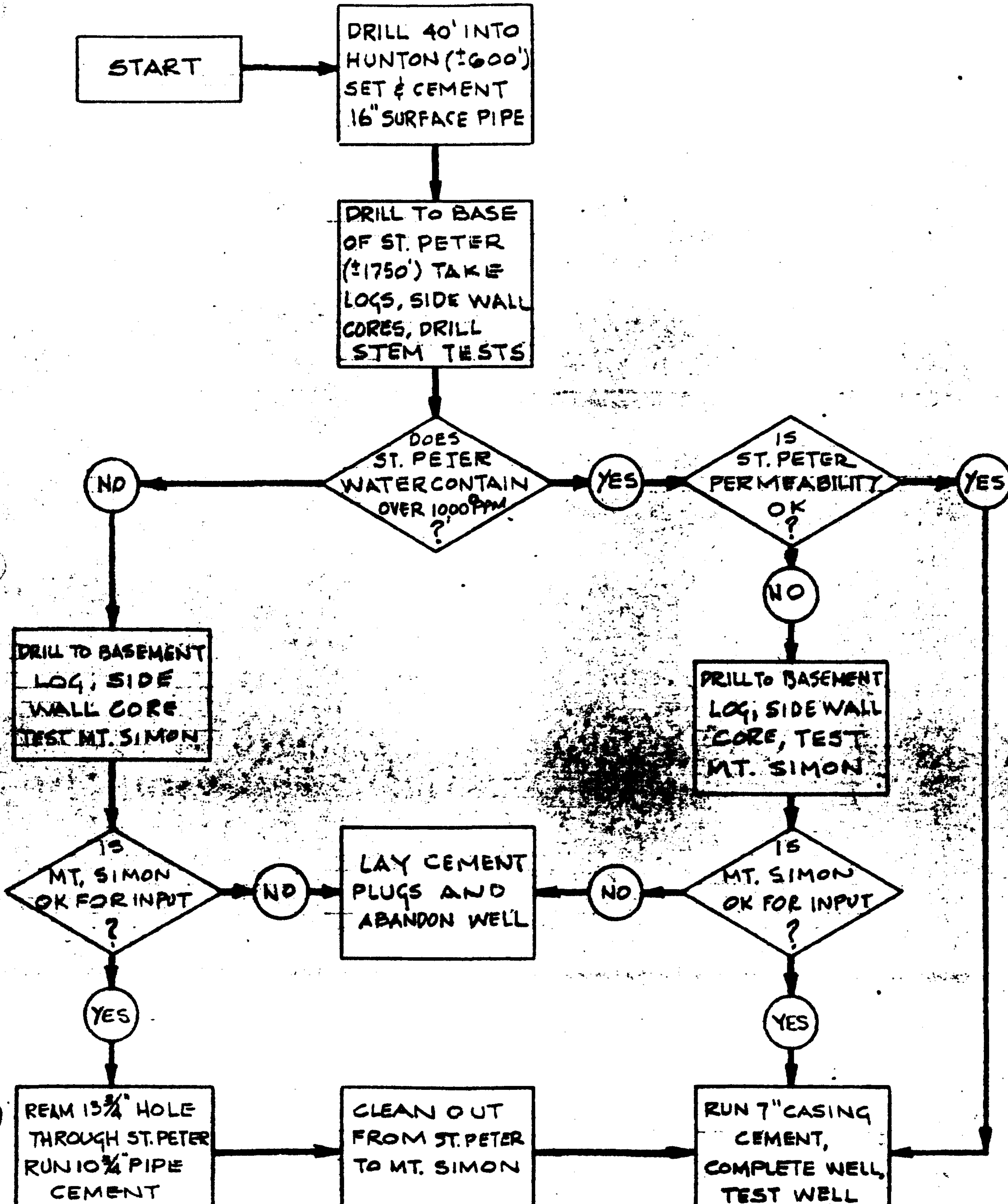
If the St. Peter carries water of less than 10,000 ppm TDS, the well will test the Mt. Simon. If this zone is satisfactory the well will be equipped with a special protective casing to cover the St. Peter plus a conventional long string of casing to complete in the Mt. Simon.

Alternate 4

If neither zone is suitable, the well will be securely plugged in accordance with good drilling practice and the appropriate Illinois regulations for abandoning exploratory wells.

Figure 1, schematic Drilling Program indicates the "decision points" to be encountered and the action to be taken at each point, depending on the test results. Details of the program [illegible] found in Appendix I.

SCHEMATIC DRILLING PROGRAM



ST. PETER SANDSTONE

As discussed in the preceding section, the first decision point involves the suitability of the St. Peter sandstone as a waste storage reservoir. To be suitable for this purpose, the sand must meet two criteria. First, the water it carries must contain more than 10,000 ppm total dissolved solids. Secondly, the sand itself must be porous, permeable, reasonably thick, and relatively free of limestone.

The lithologic properties cannot be forecast with great certainty. However, the references cited in the Feasibility Study indicate that thickness in excess of 100' and permeability on the order of 100 md. or more should not be surprising. If the connate water is sufficiently saline, therefore, this sand should be suitable.

The possibility of the St. Peter carrying potable water at this [illegible] this sand in a well some six miles to the [illegible] the east. [illegible] the salinity of the St. Peter (and many shallower zones) has been repeatedly demonstrated both in oil wells and off-structure dry holes. To the north, the Lange 3 showed low resistivity (30-40 ohms m^2/m) on the 16", 64", and 19' curves, indicating a strong brine.

To the west some fresh water has been reported by Gleason (2). His Plate I indicates potable water in the St. Peter in the extreme southwestern part of St. Louis County (44N-4E) about eighteen miles from the proposed well. His cross section A-A shows an easterly dip on all beds and projects the top of the St. Peter at about 1100' sub-sea on the west side of the Mississippi. (The correlates acceptably with 1200 sub-sea forecast in the Feasibility Study at the Sauget site.) His Figure 1 (page 13) also shows that there is at least a qualitative correlation between water mineralization in the St. Peter and depth of this sandstone; with 10,000 ppm or more being a reasonable expectation at depths greater than 500' sub-sea.

Finally, rough correlations can be made between total dissolved solids and geologic formation from Gleason's Table 2. To make this correlation relevant to Monsanto's problem, the wells should be restricted to those in Range 7 East (bordering the river).

Horizon	Total Dissolved Solids, ppm	Location	Gleason I.D. Number
Meramec Grp. (M)	488	47N-7E	3
Osage Grp. (M)	1,596	46N-7E	10
Ordivician above St. Peter	17,456	47N-7E	13
St. Peter (O) and lower	11,147	45N-7E	24

These data strongly support the conclusions of the Feasibility Study (drawn from Meents, Section V, page 36-37) that the St. Peter carries brine in excess of 10,000 ppm TDS throughout St. Clair County and that surface pipe to the Siluro-Devonian Hunton would protect all fresh water.

In spite of this preponderance of evidence, Monsanto is prepared to test the St. Peter thoroughly prior to proceeding further with this well. We will take drill-stem tests which will yield actual samples of the connate water plus valuable data on average permeability. (The rate at which fluid flows into a well during production and the rate at which bottom-hole pressure stabilizes after production ceases can be interpreted mathematically to calculate pressure-rate relationships during input.) These data will be further supported by sidewall cores (cylindrical rock samples obtained from the wall of the well) which will be analyzed for porosity, permeability and lithology. Only if positive data are at hand indicating the suitability of the St. Peter will the well be completed in this horizon.

MT. SIMON SANDSTONE

Fewer data are available on the Mt. Simon than on the St. Peter in this area because of lack of exploration to this depth. However, the greater depth (3700' vs. 1600') gives greater assurance that the connate water will be highly mineralized and that this zone will be a suitable disposal horizon at least from a conservation point of view.

The porosity and permeability of the Mt. Simon at this site are subject to question. Hence, if the well must be carried below the St. Peter, then tests similar to those described previously will be carried out in the Mt. Simon before completing the well.

WASTE CHARACTERISTICS

The waste to be disposed will consist of a mixture of the six waste streams shown in Table 1. These are the same as reported in the feasibility study, with the exception of stream 5 which has been discontinued.

The total load in Table 1 averages about 150 gpm and, as pointed out in the feasibility study, this volume may approach or possibly even exceed the capacity of the well. In the event that it is necessary to reduce the total flow to the well to stay within safe pressure limits; all or part of stream 2 will be treated and returned to the surface environment. Because stream 2 is the largest volume with the lowest contamination, this would in effect, be concentrating the waste to whatever extent this stream was diverted from the well.

The complete segregation of stream 2 would reduce the flow to the well to about 50 gpm, but would still permit subsurface disposal of about 90% of the plant's waste.

For this reason, in addition to normal fluctuations in plant operation, it is impossible to present a precise chemical analysis of the fluids to be injected. At maximum concentration the combined waste should be an aqueous solution of about 9% sulfuric acid with about 5% contamination by nitrates, benzenes, and chlorine compounds.

170 gpm

TABLE 1

W. G. KRUMMRICH PLANT

WASTE CHARACTERIZATION

STREAM NUMBER	VOLUME (GPY)	COMPOSITION % TOTAL	COMPOSITION DESCRIPTION
1	230,000	77	Sulfuric Acid
		17.6	Water
		4.8	Nitric Acid
		.6	Nitrochlorobenzene
2	55,700,000	99.5	Water
		.5	Sulfuric Acid Nitric Acid Nitrochlorobenzene
			5000 ppm
3	353,000	81	Sulfuric Acid
		19	Water
4	5,840,000	94.4	Water
		5	Sulfuric Acid
		.6	Ammelide ($C_3N_3H_3O_2NH$)
6	19,000,000	95.3	Water
		3.1	Nitric Acid
		1.4	Nitro Benzene Derivatives
7	1,090,000	65	Water
		14	Sulfuric Acid
		11	Caustic Soda Solution
		10	Chlorophenols

PROTECTIVE MEASURES

As detailed in the drilling program (Appendix E), the well has been designed so that double casings will protect any fresh water zones.

From the surface to the Hunton, a 16" OD string of surface casing will be cemented in place and tested prior to drilling deeper. This will provide permanent protection to all zones known to be carrying fresh water at this site.

If the St. Peter tests show it to be suitably mineralized and permeable, the well will be completed by setting 7" into the top of the St. Peter and cementing the annulus to the surface. Thus providing two strings (16" & 7") across all fresh water zones.

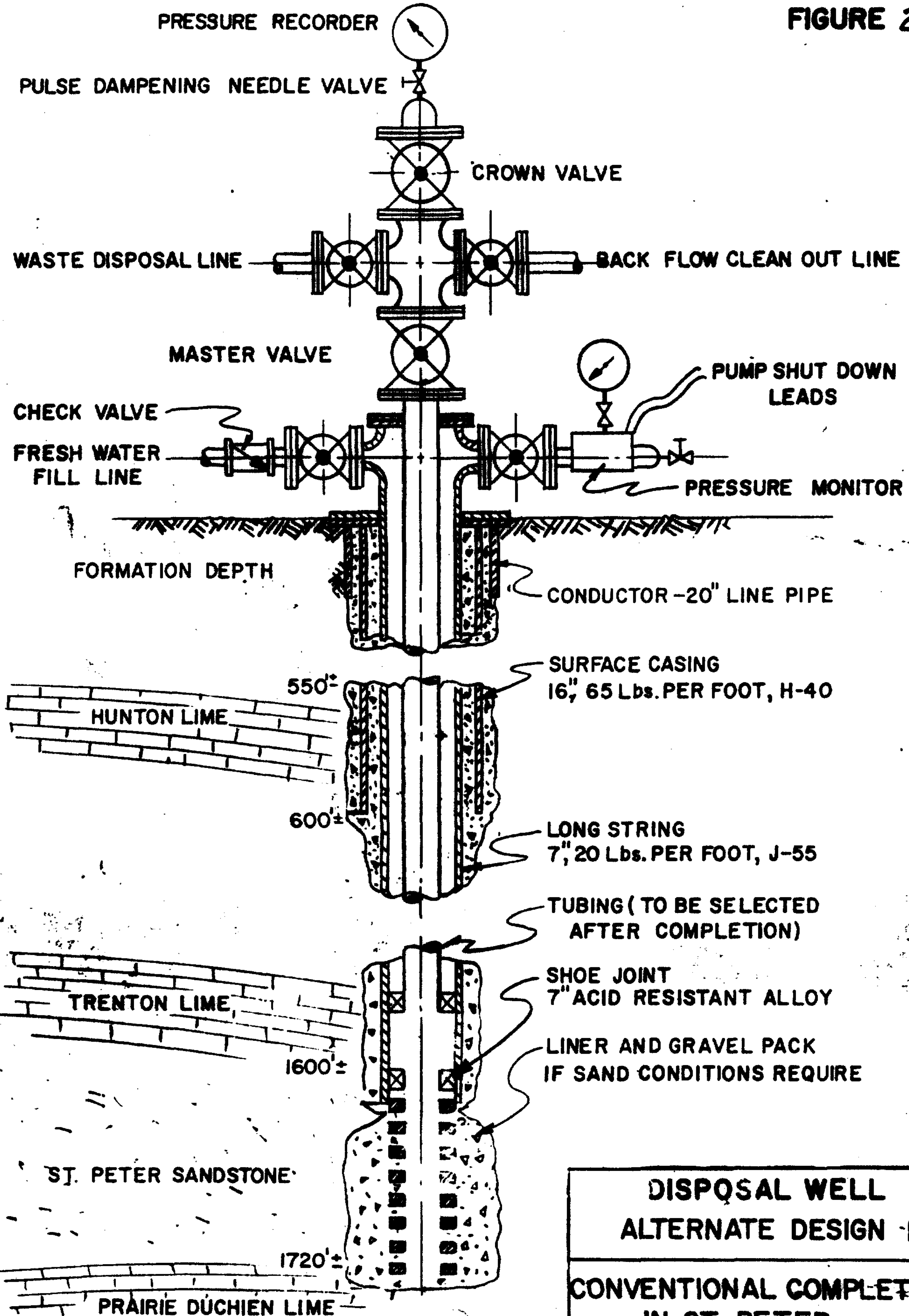
If the St. Peter contains suitably mineralized water, but lacks permeability, then an attempt will be made to complete with 7" into the top of the Mt. Simon.

If the Mt. Simon tests are acceptable, and the St. Peter contains potable water; then the hole will be reamed from the base of the surface casing through the St. Peter (or the deepest fresh water) and a 10 3/4" liner cemented from this depth back to a liner hanger inside the surface casing. The Mt. Simon completion will be with 7" casing to the surface. Thus, the upper fresh waters will be protected by strings of 16" and 7" casing and the lower fresh waters by 10 3/4" and 7" casings.

If no zone is suitable, the well will be abandoned with cement plugs opposite both the St. Peter and Mt. Simon. The 16" surface casing will be abandoned with the well with cement plugs also at the top and bottom of the casing.

Completion diagrams of all possible alternatives are shown as Figures 2 through 5.

FIGURE 2



DISPOSAL WELL
ALTERNATE DESIGN 1

CONVENTIONAL COMPLETION IN ST. PETER

NOT TO SCALE

MONSANTO BIODIZE SYSTEMS, INC.
GREAT NECK, N.Y.

MONSANTO CHEMICAL COMPANY

Department 260
Monsanto, St. Clair County, Ill.

October 7, 1944

State Water Survey
University of Illinios
Urbana, Illinios

ATTENTION —— Mr. Max Suter

Dear Mr. Suter:

The enclosed well information will furnish you with information regarding the well-water pumps at the Chemical Warfare Service Plant No. 1, Monsanto, Illinios.

This sheet covers the period September 18, 1944 to October 7, 1944.

Very truly yours,

408.90
36
372.9

375.9

353.9

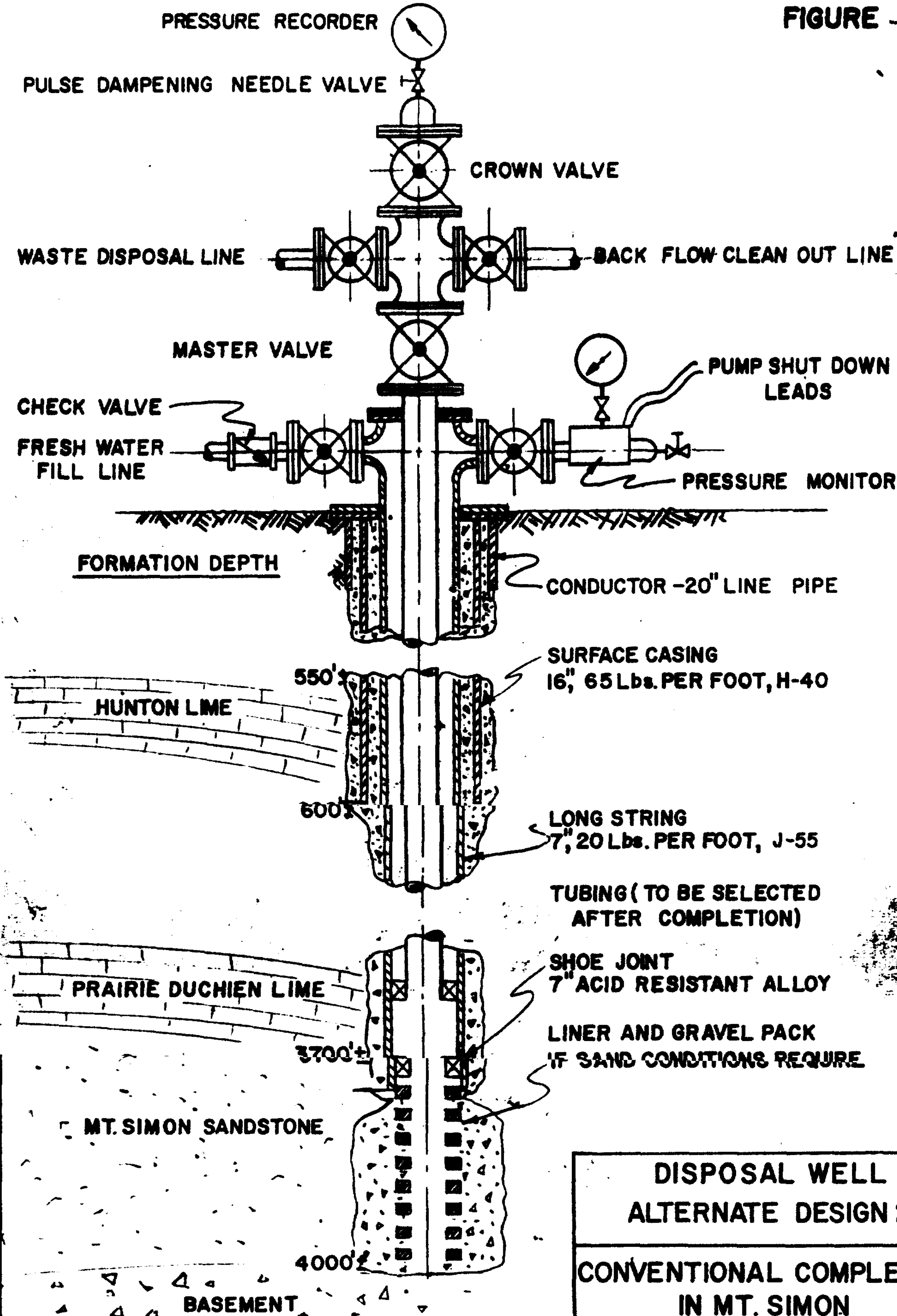
Jos. F. Stickley

Jos. F. Stickley
Manufacturing Superintentdent

Chemical Warfare Service Plant No. 1
Monsanto (St. Clair County) Illinios.

ds

FIGURE 3



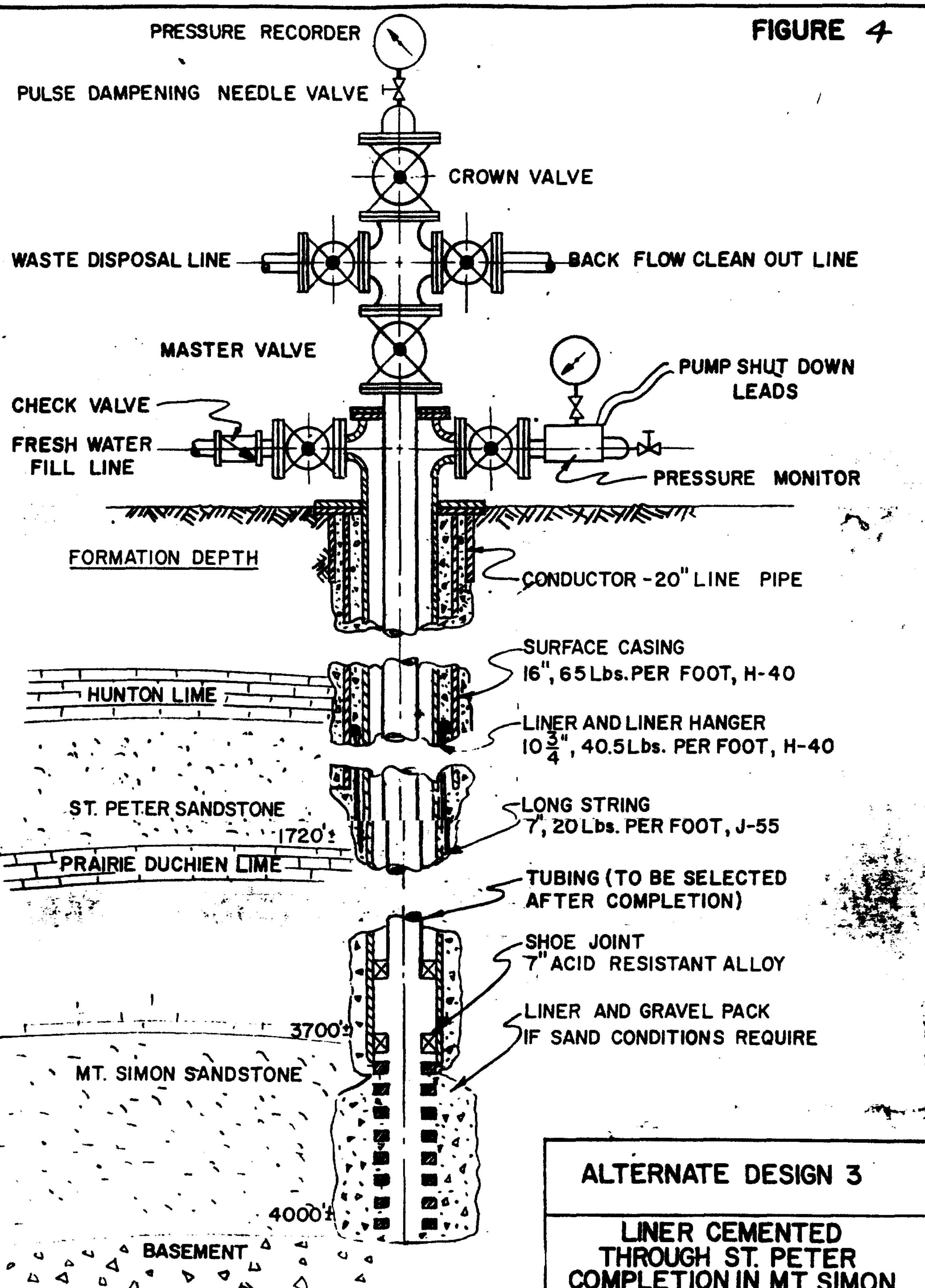
MONSANTO BIODIZE SYSTEMS, INC.
GREAT NECK, N.Y.

DISPOSAL WELL
ALTERNATE DESIGN 2

CONVENTIONAL COMPLETION
IN MT. SIMON

NOT TO SCALE

FIGURE 4



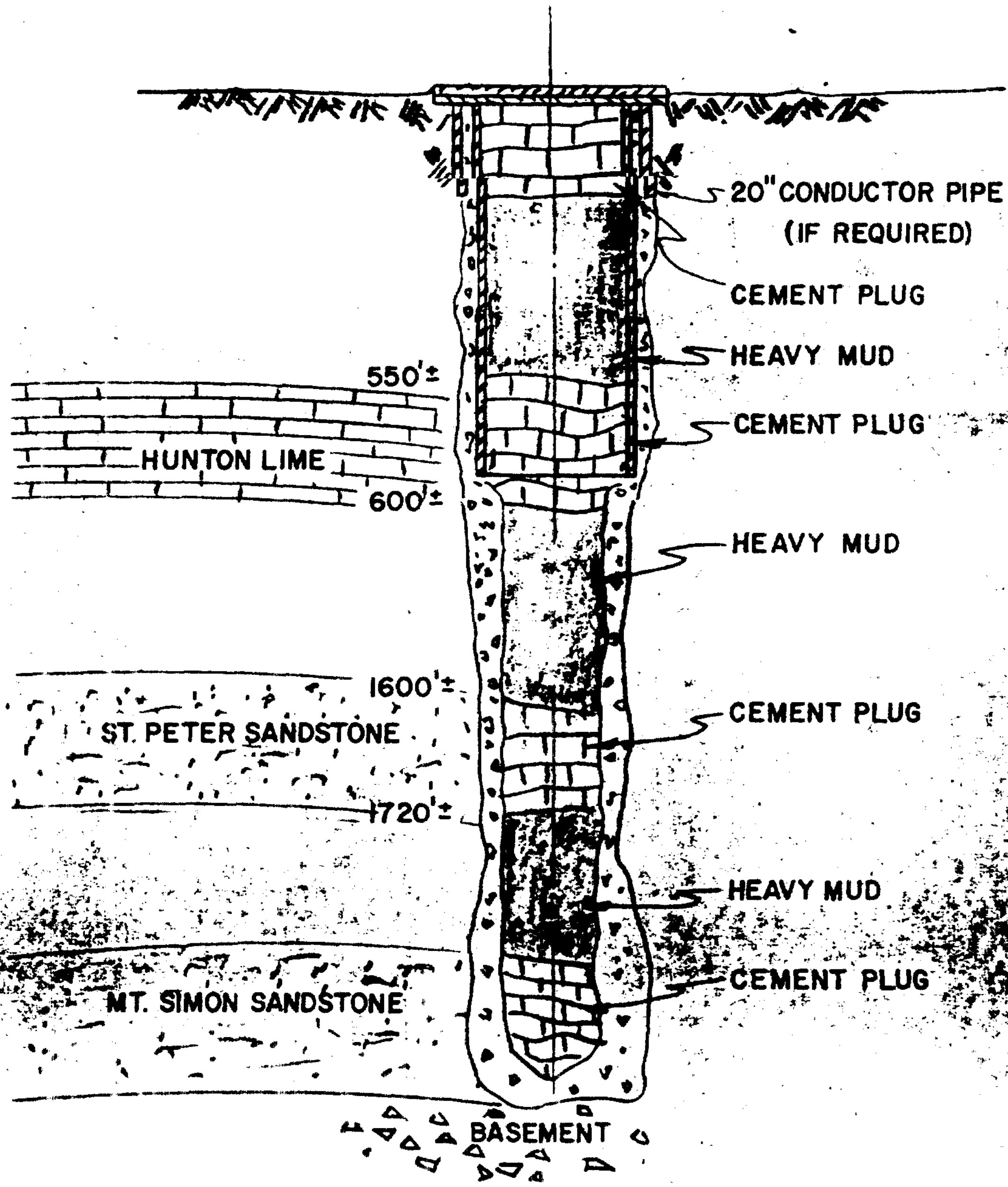
ALTERNATE DESIGN 3

LINER CEMENTED THROUGH ST. PETER COMPLETION IN MT. SIMON

NOT TO SCALE

MONSANTO BIODIZE SYSTEMS, INC.
GREAT NECK, N.Y.

FIGURE 5



MONSANTO BIODIZE SYSTEMS, INC.
GREAT NECK, N.Y.

DISPOSAL WELL
ALTERNATE DESIGN 4

ABANDONED WELL

NOT TO SCALE

PRE-COMPLETION EVALUATION

From the previous discussion, it is apparent that a critical decision must be made after penetrating the St. Peter. Enough data must be obtained in order to decide whether to complete the well in the St. Peter or to drill deeper and explore the Mt. Simon.

The principal basis for this decision will be a drill stem test of [illegible] St. Peter. A drill stem test tool is [illegible] packer, lowered [illegible] the hole on the end of drill pipe [illegible] zone of interest from the hydrostatic pressure of the mud column. They are equipped with pressure recorders.

In addition to static aquifer pressure, [illegible] proposed to swab the well at two distinct producing rates in order [illegible] establish pressure/rate relationships. The pressure drawdown below static pressure at a [illegible] producing rate [illegible]

[illegible] return [illegible] ceases, will permit accurate projections of the pressure/rate relationship if the well is completed in the zone tested. Of course, samples of the produced water will be analyzed for ionic content.

If these tests prove the suitability of the St. Peter as a disposal horizon, the results will be confirmed by taking sidewall cores.

These samples will be analyzed for porosity, permeability, and lithology.

Core points, as well as the drill stem test point, will be selected on the basis of geophysical and sample logs.

If the drill stem test of the St. Peter proves it to be unsuitable for any reason, drilling will be resumed and carried to basement. Identical tests will be carried out in the Mt. Simon before deciding upon completion or abandonment.

As discussed in the section on protective measures, an intermediate liner string will be run to provide additional protection for the St. Peter if this zone carries potable water and it is decided to complete in the Mt. Simon.

The well will be abandoned unless a suitable zone capable of accepting 50 gpm or more is encountered.

MATERIALS OF CONSTRUCTION

The disposal well must be so constructed as to maintain its hydraulic integrity under both physical stress and chemical attack.

The physical stresses which will occur in the casings during completion and operation (tensile, burst, collapse) are discussed in detail in Appendix 2. The design to meet these stresses in all cases meets or exceeds A.P.I. standards.

Chemical attack is a more serious problem. As might be supposed from the analysis of the waste, it is quite corrosive. Table 2 shows the results of exposing various metals to this waste.

On the basis of Monsanto's experience with sulfuric acid and these tests, it was tentatively decided that all critical subsurface metals will be of 316 stainless steel. The lower most joint of casing will be of this material. To protect the mild steel casing from contact with the waste, a packer with stainless steel trim will be set in the lower-most casing joint and connected to the tubing. We are currently planning on using 316 stainless for the tubing also. However, because of the cost of this material; laboratory studies will continue in an effort to find an equally suitable, but less expensive tubing.

To prevent vertical migration of the waste and possible external attack on the casing, tests were run to evaluate cement performance when exposed to this waste. The results of those tests are included as Appendix 3. From these data it appears that no problems will be encountered.

By using these materials in the well, as shown in the alternative completion diagrams, the waste will be confined by laboratory tested materials from the time it leaves the surface until it is safely disposed of in the storage reservoir.

TABLE 2

W. G. K. MATERIALS ENGINEERING

SAMPLE EXAMINATIONS

SAMPLE IDENTIFICATION	LOCATION	CORROSION RATE, MPY	DISCUSSION OF INSPECTION
Steel Welded	Liquid	17	Severe all over general cratering.
	Inter-face		Gross all over general cratering.
	Vapor		Moderate all over shallow cratering except in protected areas.
304 S.S. Welded	Liquid	<1	Very light surface etching under deposits.
	Inter-face		Same as above
	Vapor		Moderate shallow cratering in condensation areas due to lack of oxygen plus severe pits to cratering due to deposits in condensation areas.
316 S.S. Welded	Liquid	<1	Light to heavy surface etching in the deposit area only.
	Inter-face		Same as above.
	Vapor		Same as above.

POST COMPLETION TESTING

After cementing the casing(s) in place, the production test will be repeated to confirm the previous estimates of permeability, and to obtain a supply of connate water. After the pressure stabilizes, this will be injected at various rates to obtain absolute confirmation of the pressure/rate intake characteristics of the well.

Bottom hole pressures will be recorded to eliminate uncertainties due to friction losses and to establish exactly the fracturing pressure if the well is low rate.

The well will then be secured by running a temporary tubing string, loading the hole with salt water and closing the valves. All test data will be interpreted and pressure/rate/time projections will be made of future operations.

Based on these projections, a decision will be made as to what volumes and which waste streams will be disposed of in the well. Tubing and packers will then be ordered for the final completion.

These data will also be used to design the pretreatment facilities and to select the injection pumps.

REFERENCES

1. Meents, W. F. ; Bell, A. H.; Rees, O. W.; and Tilbury, W. G.
"Illinois Oil Field Brines", Illinois State Geological Survey.

2. Gleason, Charles D.
"Underground Waters in St. Louis County and City of St. Louis"
Missouri Geological Survey and Water Resources.

APPENDIX 1

DRILLING PROGRAM

A. SURFACE HOLE

1. Rig up, spud in, and set 2 to 3 joints 20" line pipe for conductor.

2. Drill 18 7/8" hole 50' into the Hunton Lime. Estimated depth 600'. Circulate and condition hole.

3. Log hole with standard IES/16" and 64" resistivity survey.

4. Run 16", 65#, H-40 casing and set 3' off bottom. Use float shoe with centralizers 6' above the shoe and 6' below the collar of the shoe joint. Place centralizers on joints 2,3,4, and 5 below ground level. Baker -- lock shoe joint at both ends.

5. Install single plug cementing head. Break circulation and check that casing is free. Pump 10 barrels of fresh water.

6. Mix and pump sufficient cement to obtain 150% of theoretical fill-up. (Exact volume will depend upon hole conditions and depth, but should be between 350 and 500 sacks)

7. Drop top plug and displace with water using cementing trucks for displacement. Reciprocate pipe until weight indicator shows sticking.

8. Wait on cement 16 hours. Install casing head at ground level and nipple up blow out preventers. Test BOP's to 1,000 psi before drilling shoe.

B. ST. PETER TEST

1. Drill shoe and test surface cement job with 500 psi against BOP's, drill 9 7/8" hole to base of St. Peter Sand (estimated at 1720'). Catch and sack samples at 10' intervals from surface pipe through St. Peter. Upon reaching base of St. Peter circulate and condition hole for logging.

2. Log hole with IES/16" and 64" resistivity/micro log/ gamma log from T.D. to surface casing shoe.

3. Make up anchor type drill stem test tool with dual pressure recorders, circulating ports and safety joints. Space packer element to set in lowest competent section of Trenton Lime. Run tools and take conventional DST. Produce well for two hours at constant rate (swab, if necessary). Allow to stabilize for final static pressure.

4. Recover test tools. Analyze water sample for total dissolved solids. Make field analysis of DST to estimate intake capacity of St. Peter.

sample for detailed mineral anal SWS in any event

5. If analyses indicate St. Peter is a suitable disposal horizon, take side wall cores based on logs and samples and proceed with section F, Completion; otherwise, go to Section C, Mt. Simon Test.

C. MT. SIMON TEST

1. Continue 9 7/8" hole to basement (estimated at 4,000'). Catch and sack samples at 10' intervals. Upon reaching basement, circulate and condition hole for logging.

2. Log hole with IES/16" and 64"/resistivity/micro-log/ gamma log from T.D. to top of St. Peter.

3. Make up anchor type drill stem test tool with dual pressure recorders, circulating ports and safety joints. Space packer element to set in lowest competent section of Prairie du Chien (Arbuckle) Lime. Run tools and take two hours at constant rate (swab, if necessary). Allow to stabilize for final static pressure.

4. Recover test tools, analyse water sample for total dissolved solids. Make field analysis of DST to estimate intake capacity of Mt. Simon. gal sample for SWS

5. If analyses indicate Mt. Simon is unsuitable for use as a disposal horizon; proceed with Section D, Abandonment. If analyses indicate Mt. Simon is a suitable disposal horizon, take side wall cores. If St. Peter contains mineralized (10,000 + ppm TDS) water; proceed with Section F, completion. Otherwise, go to Section E, Liner Procedure. in any event

D. <u>ABANDONMENT</u> - (If both zones unsuitable)

1. Run in tubing or drill pipe open ended. Lay neat cement plug from total depth to top of Mt. Simon.

2. Spot heavy mud from top of Mt. Simon to base of St. Peter.

3. Lay cement plug from base of St. Peter to top of St. Peter.

4. Fill hole with heavy mud to surface casing.

5. Spot 20 sack cement plugs at base of surface casing and at top of well.

6. Cut off casing to 1 foot below ground level and clean up location.

E. LINER PROCEDURE-(If St.Peter water is potable)

1. Spot temporary cal-seal plug 50' below base of St. Peter (or lowest potable water) to protect Mt. Simon during liner operations.

2. Ream 9 7/8" hole to 13 3/4" from surface casing to 10' below base of St.Peter (or lowest potable water).

3. Make up and run liner of 10 3/4", 40.5 pound per foot H-40 casing with wash down float shoe and left handed circulating sub. Liner to extend from reamed T.D. to 50' inside surface casing. Centralizers are to be installed across St. Peter section, inside surface casing, and as indicated by logs. Centralizer and scratcher program will be prepared on site.

4. Break circulation and pump 10 barrels of fresh water.

5. Mix and pump sufficient cement to obtain 150% fill-up behind liner. Exact volume to be calculated on the basis of caliper survey (run in conjunction with micro-log), but will probably be about 600 sacks. Reciprocate pipe while cementing.

6. As last cement clears the well head, open circulating ports and circulate out excess. When returns are clear break out left handed sub and pull drill pipe.

7. Wait on cement 16 hours.

8. Drill out shoe, clean out cal-seal plug and condition hole for completion. Go to Section F, Completion.

F. COMPLETION (Either St. Peter or Mt. Simon)

1. Make up casing string to consist of (bottom to top):

   One Formation Packer Shoe

   One Joint 7" special alloy pipe (see materials section)

   Balance of string 7" 20 pound per foot, J-55, casing. Scratchers and centralizers to be installed as indicated by logs.

2. Tally pipe in the hole and position packer in top three feet of disposal horizon. (This may be varied slightly if caliper indicates washed out zone.) Circulate until clean returns are obtained.

3. Drop ball and pressure up casing to 1,000 psi to set packer and open cementing ports. Pump 10 barrels of water.

4. Mix and pump sufficient cement to provide 150% of theoretical fill-up. (Exact volume to be calculated on site) Pump cement at maximum rate that is within pressure limits of casing and packer.

5. Drop top plug and displace with water using cementing trucks. Bump plug with maximum of 2,000 psi. Hold pressure for two minutes. Bleed off and check float valve. If OK, drop slips and seal assembly. Slack off weight on pipe elevators, cut off casing. Wait on cement 24 hours.

6. If cement did not circulate, run temperature survey after six hours and squeeze if necessary.

7. Drill out float equipment and clean out to total depth. Circulate out all mud and leave hole full of water. Lay down drill pipe. Run tubing with air lift valves (or perforated nipples) and packer with bell nipple on bottom. Install head, release rig.

G. TESTING

1. Run sub-surface pressure recorder with 72 hour clock to 30' above casing shoe.

2. Test well on air lift for 10-12 hours. Last half of test should be at constant rate.

3. Shut well in for period equal to test period. Tag bottom with pressure bomb, to check for fill. Pull pressure bomb, change charts and re-run.

4. Load hole with produced water. Close in casing side. Hook up pump truck. Take 5 hour variable rate injection test and 5 hour constant rate injection test.

5. Shut well in for 10 hours. Pull pressure bomb. Shut well in.

6. Based on tests; tubing size, pump design, and pre-treatment design will be finalized.

APPENDIX 2

CASING SAFETY FACTORS

Casings cemented in any well are subject to three distinct types of stress; tension, burst, and collapse. These occur during different phases of the well's useful life and safe design must provide for adequate strength under maximum conditions for each type of stress. Maximum tension will occur while running the casing, when the entire string is suspended from the derrick. Maximum collapse stress will occur if future remedial work requires that the well be swabbed dry (no fluid in the well) and thereby subjected to geo-hydraulic collapse pressures from aquifers. Maximum burst stress in the long string of an injection well will occur during input operations. Maximum burst stress of shallower strings are likely to occur during cementing operations.

Because of the need to use standard sized sub-surface tools, bits and other equipment, steel well casings are manufactured in standard (American Petroleum Institute) sizes. Since it is impossible to replace casing cemented in the well, the A.P.I. specifications are quite rigid in such matters as minimum yield strength, minimum joint strength, maximum and minimum wall thickness, minimum drift diameter inside, etc. The A.P.I. also recommends minimum safety factors.

Surface Casing - 16", 65#/ft, H-40 set at 650'

Tension:

Minimum Joint Strength = 423,000 pounds

Maximum Weight (neglecting bouyancy)

650' x 65#/ft. = 42,250 pounds

Actual Safety Factor $\frac{423,000}{42,250} = 10.0$

Recommended Safety Factor = 1.8

Collapse:

Minimum Collapse Resistance = 630 psi

Maximum Collapse Pressure

650' x 0.50 psi/ft. = 325 psi

Actual Safety Factor $\frac{630}{325} = 1.94$

Recommended Safety Factor - 1.125

Burst:

Minimum Internal Yield Pressure = 1640 psi

(Based on 87½% yield strength)

Recommended Safety Factor = 1.00

Maximum Well Head Pressure = 1640 psi

(This casing will have a cement sheath inside as well as outside during injection operations. Thus,

the 1640 psi restriction is
applicable only to pressures
before setting the long string)

<u>Intermediate Casing (if required) 10 3/4", 40.5#/ft.,H-40, set at 1750</u>

<u>Tension:</u>

Minimum Joint Strength = 338,000 pounds

Maximum Weight (neglecting bouyancy)

1750' x 40.5#/ft. = 71,000 pounds

Actual Safety Factor = $\frac{388,000}{71,000}$ = 4.75

Recommended Safety Factor = 1.80

<u>Collapse:</u>

Minimum collapse resistance = 1340 psi

Maximum collapse pressure

1750' x 0.50 psi/ft. = 875 psi

Actual Safety Factor = $\frac{1340}{875}$ = 1.53

Recommended Safety Factor = 1.125

<u>Burst:</u>

Minimum Internal Yield Pressure

(Based on 87½% yield strength) = 2280 psi

Recommended Safety Factor = 1.00

Maximum Well Head Pressure = 2280 psi

(This casing will have a cement sheath inside as well as outside during injection operations. Thus, the 2280 psi restriction is applicable only to pressures before cementing long string.)

Long String - 7", 20#/ft., J-55 to 4,000'

Tension:

Minimum Joint Strength = 254,000 pounds

Maximum Weight (neglecting bouyancy)

4000' x 20#/ft. = 80,000 pounds

Actual Safety Factor $\frac{254,000}{80,000} = 3.18$

Recommended Safety Factor = 1.80

Collapse:

Minimum Collapse Resistance = 2500 psi

Maximum Collapse Pressure

4000' x 0.50 psi/ft. = 2,000 psi

Actual Safety Factor $\frac{2500}{2000} = 1.25$

Recommended Safety Factor = 1.125

Burst:

Minimum Interal Yield Pressure

(Based on 87½% yield strength) = 3740 psi

Maximum Well Head Pressure

(Based on 1.00 psi/ft. fracture

gradient and fresh water column)

St. Peter 1600-(1600x.433) = 905 psi

Mt. Simon 4000-(4000x.433) = 2270 psi

Minimum Safety Factor $\frac{3740}{2270} = 1.65$

Recommended Safety Factor = 1.00

CHEMICAL RESEARCH AND DEVELOPMENT DEPARTMENT

HALLIBURTON [illegible]

DUNCAN, OKLAHOMA

LABORATORY REPORT

[illegible]
Sample No. 26

To Mr. Weldon Baker

Halliburton Services

Evansville, Indiana

Date February 5, 1971

This report is the property of Halliburton Services and neither it nor any part thereof nor a copy thereof is to be published or disclosed without first securing the express written approval of laboratory management; it may however be used in the course of regular business operations by any person or concern and employees thereof receiving such report from Halliburton Services.

We give below results of our examination of effluent sample for Monsanto Krummich Plant, Sauget, Illinois

Submitted by Mr. Weldon Baker

Marked For Mr. Reed W. Payne, Monsanto Biodize Systems, Inc.
510 Northern Blvd., Great Neck, N. Y. 11021

Purpose

To determine the effect of this acid effluent on cementing compositions for disposal wells.

Conclusions

This series of tests were initiated December 31, 1970. As of this date, all cementing compositions tested have shown no evidence of deterioration. Previous long term test data have shown that Resin Cement is stable in sulfuric acid concentrations up to 5%. Since this effluent sample contained only 1% sulfuric acid, Resin Cement should be adequate, but if waste effluents at some future date could potentially contain more than 5% sulfuric acid, then the HLX-116 slurry would be recommended.

Sample No. 28

Scope and Procedure

Test specimens were prepared according to API RP 10B, "Recommended Practice for Testing Oil-Well Cements and Cement Additives," cured 72 hours at 80°F and then immersed in the effluent with test temperature maintained at 80°F. Test cells are recharged with fresh effluent if depletion is indicated.

Data

Acid Effluent

Monsanto Krummich Plant
Sauget, Illinois

Chemical Analysis

Specific Gravity - 1.004 @ 78°F
pH - 1.12
Sulfuric Acid - 1.01% by weight

Hydroxide - 0 MPL
Carbonate - 0
Bicarbonate - 0
Chloride - 480
Sulfate - 11,400
Calcium - 80
Magnesium - 24
Sodium - 750
Total Dissolved Solids - 17,700
Iron - 8

Cement Recommendation

Resin Cement, or
HLX-116 Slurry (experimental material)

cc: F. C. Moody, A. A. Baker, Reed W. Payne ✓, F. M. Anderson, D. K. Smith

Respectfully submitted,

Laboratory Analyst
Watson-Underwood

HALLIBURTON SERVICES
By Homer F. Waggoner

RICHARD B. OGILVIE
Governor

① + ~~[illegible]~~
② F regr. File

STATE OF ILLINOIS

WILLIAM L. BLASER
DIRECTOR

ENVIRONMENTAL PROTECTION AGENCY

August 5, 1971

MONSANTO COMPANY - W. G. Krummrich Plant
Deep Well Disposal

Monsanto Company
Sauget,
Illinois 62201

Attention: Mr. Gerald L. Bratsch
Plant Manager

Gentlemen

This Agency, along with the Illinois State Geological Survey and the Illinois State Water Survey, have reviewed your proposal for your deep well disposal design at the W. G. Krummrich Plant in Sauget, Illinois. We offer the following comments and requests which we felt should be brought to your attention and fulfilled prior to the issuance of a permit to start your drilling operations

1. Enclosed please find two copies of EPA-WPC-7 (Permit Application for Industrial Waste Treatment). Please complete these in full and return to this Agency so we may complete review of your application for a permit.

2. There is some concern over the probable confining competence of the cap rock above the St. Peter sandstone, which would presumably be the Joachim Dolomite. We believe it is essential to cut a few cores in the interval from 70 feet above the St. Peter to the top of the St. Peter to show the nature of the cap rock. It is considered important to demonstrate by coring the range of lithologies within the Joachim Dolomite - at more permeable zones as well as the less permeable zones.

3. The coring program should also demonstrate the range of lithologies of the reservoir rock, either the St. Peter sandstone or the Mt. Simon sandstone. If the side wall cores can be subjected to the same kinds of laboratory permeability tests as down the hole cores, the side cores would be satisfactory, but permeable as well as impermeable zones should be cored, as inferred from the geophysical logs.

4. We have required that swab samples, rather than drill-stem test samples, be used for conate water determinations. The swabbing should continue until the composition of the produced water is constant. We require that this Agency be notified when the swabbing equipment is ordered so that we have the opportunity of being present for collection of samples and reviewing field conductivity tests to determine the total dissolved solid levels.

5. There is much uncertainty about the composition of the injected waste. On Page 19, 9 percent sulfuric acid is mentioned. The Halliburton Report mentions one percent sulfuric acid. A 9 percent acid would probably sink through the native brine in the formation whereas a one percent acid may rise, depending on the specific gravity of the brine.

6. Two additional points we feel should be subject to further clarification are the facilities for the controlling and monitoring of the annular pressure around the injection tubing and the establishing of the fracture pressure. Please clarify these points with additional information.

7. In addition to the elimination of waste stream #2, what additional flexibility and/or pretreatment facilities are being provided?

8. In the event of maintenance problems in the well, what storage facilities are going to be provided so that alternate means of waste disposal will not be necessary?

9. Mr. H. F. Smith, Head of the Hydrology Section of the Illinois State Water Survey, asks that a sample of the water that is swabbed from the St. Peter formation and also from the Mt. Simon formation be sent to him for analysis when it is taken. We would ask that this be sent to him so that they can obtain further information regarding the ground waters of the State of Illinois.

Upon receipt of the information requested above and acknowledgement that consideration will be taken for the above-mentioned comments, a review of your proposal will continue. Should you have any questions or comments regarding the above, please advise.

Very truly yours,

DIVISION OF WATER POLLUTION CONTROL

Ward L. Akers
Acting Manager
Permit Section

REB bap
CC - Survillance Section Collinsville Office
Illinois State Geological Survey
Attention Dr. Robert Bergstrom
Illinois State Water Survey
Attention Mr. H. F. Smith

Monsanto

Monsanto Company
Sauget, Illinois 62201
Phone: (618) 271-5835

January 20, 1970

Mr. Clarence Klassen
Technical Secretary
State Sanitary Water Board
Springfield, Illinois 62706

Dear Mr. Klassen:

The Wm. G. Krummrich Plant of Monsanto Company hereby applies for an operation permit to construct a waste-water injection well to be located at the plant site in Sauget, Illinois.

The enclosed report includes preliminary geological and engineering data concerning the construction of proposed deep well disposal facilities. The report states that subsurface disposal is feasible in the St. Peter's and Roubidoux Sand of Ordovician Age and the Davis and Bonneterre Dolomite of Cambrian Age.

Should a permit be granted, the program for an exploratory well as detailed in the report will be followed.

Respectfully,

G. L. Bratsch
Plant Manager

/jo
Enclosure

Ill. St. Water Survey
Attn H. Smith

PROPOSAL FOR WASTEWATER INJECTION WELL

AT MONSANTO COMPANY, W.G.KRUMMRICH PLANT

SAUGET, ILLINOIS

PREPARED FOR

ILLINOIS SANITARY WATER BOARD

BY

MONSANTO COMPANY

TABLE OF CONTENTS

PROPOSAL FOR WASTEWATER INJECTION WELL AT

MONSANTO COMPANY, W.G. KRUMMRICH PLANT, SAUGET, ILLINOIS

PURPOSE - The purpose of this report is to present the available geological and engineering information concerning subsurface disposal of liquid waste at Monsanto's W. G. Krummrich Plant, Sauget, Illinois to the State of Illinois Sanitary Water Board.

SCOPE - The scope of this study includes a discussion of the subsurface geology in the area of the plant site as to the possibility of a porous and permeable brine saturated reservoir rock suited for liquid waste disposal. Also included is a history of drilling in the area.

LOCATION - Monsanto Company's W. G. Krummrich plant is located at Sauget, Illinois which is in St. Clair County.

HISTORY OF DRILLING IN AREA -

Figure 1 on Page shows the location of four deep wells that have been drilled in the St. Louis area.

Well #1 (Lange #3) is used by Laclede Gas for gas storage; well #2 (Asylum Well) was drilled in an attempt to find water for an asylum in south St. Louis, and wells #3 (E.F.Kircheis #S-1) and #4 (Theobald #A-15) were drilled for gas storage by Mississippi River Fuel Company.

Each of the above four wells penetrated at least 2700 feet of sediment. Also, the wells have good driller logs and sample descriptions which allows a reasonable prediction of what might be encountered at the plant site. The logs of these wells are listed in Table 1 and are available upon request for examination. Also attached as Figure 2 is the sediment log for the Lange #3 well.

POSSIBLE DISPOSAL ZONES

Logs of the above wells have been reviewed by Monsanto Company's Hydrocarbon's Division. They state that several strata suitable for disposal of waste materials should be encountered by drilling a disposal well. The most likely zones for disposal would be the St. Peter's sand found in the Asylum Well @ 1452 feet and the Robidoux Sand @ 2102 feet in the Asylum Well.

The data also indicates that an additional area to be considered is the Davis-Bonneterre dolomite @ 3000 feet in the Asylum Well.

Included in the log of the Asylum Well published by G. C. Brodhead in 1878 was a description of the water encountered. Brodhead says:

> When the borings began, the water in the well stood at 40 feet below the surface; at 134 feet an 8 or 10 inch opening was struck and the water sank in the well to a depth of 128 feet. Salt water was obtained at 1,220 feet. At 1,225 and 1,262 feet from the surface a strong petroleum smell was recognized. Sulphur water was reached at 2,140 feet. At 2,256 the water in the sand pump indicated 3 per cent of salt; at 2,957, 4 1/2 per cent; at 3,293, 2 per cent; at 3,367, less than 2 per cent; at 3,384 feet, 3 per cent, and below 3,545, 7 to 8 per cent.

In an article entitled "Deep Well Disposal of Industrial Wastes in Missouri", by Dr. W.C.Hayes, State Geologist, Dr. Hayes states that "the Missouri Geological Survey considers the St. Louis area geologically feasible for the construction of liquid waste disposal wells".

Therefore, the aforementioned references indicate that strata suitable for waste injection should be found in the area of the W. G. Krummrich Plant.

CHARACTERISTICS OF WASTEWATERS

Present Requirements:

At the present time, the W.G.Krummrich plant is proposing to dispose of the following materials in an injection well:

1) 2.4 million pounds per year of 85% acid - 15% organic mixture.

1.1 mg/yr 2) 8.8 million pounds per year of 85% H_2O - 15% organic mixture.

The flow rate for the above figures averages approximately 3 gpm.

Future Requirements:

If the construction of an injection well is successful, its future use would be valuable for the disposal of waste materials which are either detrimental to or not destroyed by biological waste treatment processes.

PROGRAM FOR EXPLORATORY WELL

If an exploration permit is obtained from the State Sanitary Water Board for the construction of an exploratory injection well, the following program would be implemented:

1. Compliance with all permit requirements.
2. Complete detail characterization of waste materials.
3. Conduct necessary corrosion tests.
4. Prepare final design of wells and of any above ground pretreatment facilities which may be needed.
5. Resubmit detail design plan to State for preliminary approval.
6. Award drilling, testing and completion contract for exploratory well.
7. Perform compatibility and capacity tests.
8. Submit formal application for operation of injection well.
9. Install complete facilities.

CONCLUSIONS:

Data from drilling logs of four wells in the area of the W. G. Krummrich Plant indicate that the subsurface strata is suitable for disposal of waste materials.

Formations exist at depths of 1452, 2102, and 3000 feet which are both semi-permeable and contain brine or sulfureted water. Thus, the injection of waste material into one of these strata would not contaminate any source of potable water.

LIST OF TABLES AND FIGURES

TABLE 1

GEOLOGIC LOGS OF DEEP WELLS IN ST. LOUIS AREA

Well	Location	Logs Available
Lange #3	6-47N-7E	Micro Log Electrical Log Sediment Column
Theobald #A-15	35-1S-10W	Electrical Log
Kircheis #S-1	27-3N-6W	Radiation Log Sonic Log Microlog Micro Laterolog Induction-Electrical Log
Asylum	31-45N-7E	Sediment Column